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EQUIPMENT

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DESIGN PARTICULARS OF THE SUCTION SYSTEMS IN BATCHING-MIXING LINES

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The design particularities of the suction systems in batching-mixing lines are examined and different mechanical solutions which increase the efficiency of combined operation of suction and technological equipment in glass batch production are presented.

Key words: suction system, bag filter, weighing batcher, mixer, gathering conveyer.

The appearance of a wide standard series of compact bag filters equipped with built-in fans and automatic control of the regeneration of filter elements has greatly simplified the process of designing and building highly efficient suction systems for batching-mixing and transport-technological lines in batch houses. Small-size local bag filters placed in pouring locations and locations with the greatest dusting of loose materials are now used instead of centralized suction systems consisting of one or two powerful fans, several steps of individual or multiple cyclone separators as well as a cumbersome filter and branching network of air pipelines with regulatable and nonregulatable disk valves and slide-knife gate valves. The placement locations in the batching-mixing lines (BML) are the gathering conveyer, onto which the main components of the glass batch are loaded during batching, and the mixers, in which these materials as well as coloring and de-coloring agents, which are usually delivered directly into the molten glass, are mixed and wetted in accordance with a prescribed sequence diagram.

Ordinarily, a single bag filter is placed in the batching line; the filter is placed closer to the mixer and sometimes mounted directly on the cover of the power drive station of the gathering conveyer. Less often, if there are more than five or six batchers and the gathering conveyer is longer than 30 m (horizontal assembly of the batch house), an additional dust-catching assembly shifted toward the center or tail end of the conveyer is used.

In some cases a bag filter placed at the head of the gathering conveyer is connected with the mixer by means of a separate air pipeline and removes dust from the batching and mixing processes simultaneously, creating the required rarefaction not only inside the cover of the working space of the conveyer but also in the batch mixer. However, this dust-catching system is not always used; this is largely determined not by technological utility but rather by the cost of on acquiring and assembling expensive suction equipment.

Since relatively high-capacity filters with a large filtration area of the bag elements (see Table 1) are required to remove the excess volume of dusty air displaced from the mixer by the loaded materials and the pores in the filtration fabric rapidly become clogged when the batch is wetted with water and possibly heated by steam, it is desirable to install autonomous filters or other suction apparatus connected only with the mixers and not with other process equipment in the BML. In addition, suction apparatus must have filtration elements made of a special fabric with an oil-moisture protective coating which decreases its rapid soaking and contamination.

As a rule, in the standard scheme for joining a bag filter with the batch mixer (Fig. 1) the air to be cleaned is delivered from the bottom into the filter *1* and the regenerated dust is discharged at the bottom into the mixer *2* through the same connecting air duct *3*, equipped with one or two pneumatic cut-off slide gates *4*. Even a single slide gate makes it possible to effectively cut the operating filter off from the mixer after dry mixing of the glass batch components has been completed and thereby protect the filter fabric from intense evaporation of heated water during wetting of the mixture.

When two successively positioned disk slide gates, forming a sluice gate, are used the negative effect of the moist and

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TABLE 1. Technical Characteristics of the Filters in Mixer Suction Systems

Mixer volume, liters	Filter characteristics					
	Filter type*	Capacity, m^3/h	Filtration area, m^2	Fan power, kW	Dimensions, m	Mass, kg
750	FC2J07	500	7	0.75	∅ 600; H = 1.48	85
1500	FC2J13	1000	13	1.1	∅ 600; H = 1.9	126
2250	FC3J20	1500	20	1.5	∅ 800; H = 1.84	164
3000	FC4J25	2000	25	2.2	∅ 1000; H = 1.67	219
4500	FC4J39	2500	39	2.2	∅ 1000; H = 1.92	243

* WAMECO series cylindrical air filters from the WAMGROUP concern (Italy).

dusty air on the filter and the top slide gate of the sluice is reduced to a minimum.

However, if there is no cut-off slide gate in the process scheme of the BML and the batch is produced in the dry mixing regime (this regime is most efficient in the TEKA and EIRICH mixers), then in order to decrease the negative effect of the moisture on the surface of the filtration elements automatic shut-off of the filter's fan during the entire time from the start of wetting of the batch to the completion of batch loading into the receiving hopper is required. But this solves the indicated problem only partially and does not eliminate the need for more careful prophylactic checking of suction equipment operation, since the bottom part of the filters, which are located in the discharge zone of the regenerated dust, still becomes covered with drops of moisture and gradually becomes covered with a crust consisting of soda, dolomite and other most highly dusting components of the glass batch.

Such build-up, which impedes the normal operation of the filtration elements, forms especially rapidly when the conventional mixing technology, in which sand is wetted first in the mixer and then the remaining materials of the mixture are loaded, is used. In this case it is pointless to install a cut-off disk gates on the suction connection because the excess air displaced from the mixer when the quartz sand is loaded remains dry only initially before water spraying to wet the batch starts. Naturally, in this regime for removing dust from moist air the filters become clogged in 5 – 7 days of operation and without careful additional cleaning (automatic regeneration is no longer helpful) even washing the bags no longer works.

Interestingly, in domestic and foreign practice of glass batch preparation the process of removing dust from the air displaced from the mixer during batch loading and mixing of raw materials is also carried out using other, less expensive materials compared with bag filters and suction apparatus and methods. The simplest such apparatus (Fig. 2) is the aeration bag *1* made of fabric which is impenetrable to dust. This bag acts as an expander and its volume is comparable to that of the material loaded into the mixer *2*. The drawback of such bags, which often come as inexpensive options with many brands of foreign mixers, is that it collapses when the

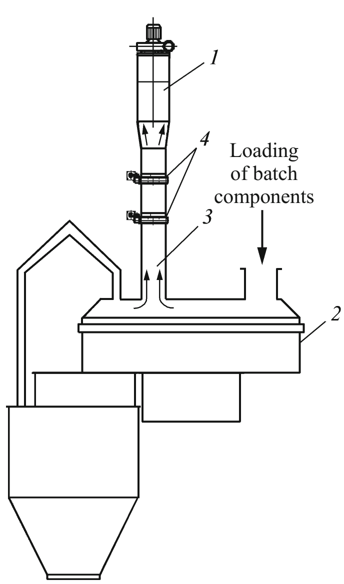

Fig. 1. Scheme for joining the bag filter with the mixer.

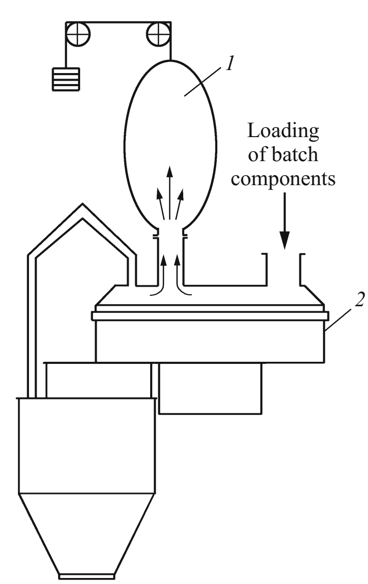

Fig. 2. Aeration expansion bag apparatus on a mixer.

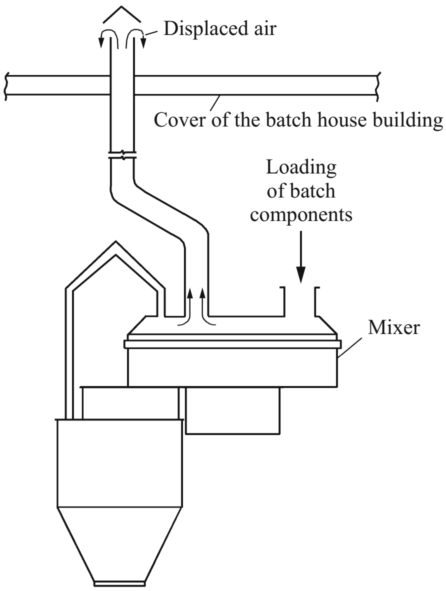

Fig. 3. Installation of an aeration exhaust tube on a mixer.

batch is loaded after being mixed, and as a result part of the dusty air concentrated in the bag is discharged into the delivery station of the gathering conveyer, producing undesirable dusting. The discharge is partially localized, if before the batch is off-loaded the deflecting gate of the bag switch, located between the gathering conveyer and the mixer, is transferred into a position where the material is loaded into another mixer, which is possible only if the BML is properly equipped for this and the weighing line operates on two mixers. Other negative aspects of the operation of suction systems based on aeration bags are weak aeration of the interior volume and moist batch constantly sticking to the wall and rotary elements of the mixer, which must be regularly cleaned at the end of each work shift.

The same drawbacks also inhere in a different design of an air volume expander, made from filtration fabric stretched on a light metal framework and forming a kind of cylindrical sleeve with limited volume $0.5 - 0.8\ m^3$. In contrast to an aeration bag the sleeve fabric does not collapse and passes filtered air, but as all filters it also rapidly becomes clogged, though the filter is replaced and scrubbed much less often — once in two months.

The best aeration of the interior volume of a mixer during preparation of glass batch is achieved with a simple 200 – 300 mm in diameter exhaust pipe (Fig. 3), which discharges a plume of excess moist air into the atmosphere at height 12 – 16 m. Sometimes, when the volume of the pipe must be increased considerably, for example, for mixers with volume greater than 1500 liters and with a vertically position batch house where large portions of material are rapidly loaded into a mixer, an expansion tank or cyclone separator, which also allows dust to settle, is added at the pipe cut-off. Excess air is removed from this tank and the required rarefaction is provided in the system by either natural drawing (Fig. 4*a*) or a fan (Fig. 4*b*), whose rate of revolution can be varied by using a frequency regulator installed in the motor. True, when using natural or forced drawing of the exhaust tube there is a danger that a portion of the light-weight fractions of the batch will volatilize so that in some production plants the outlet of the expansion tank does not open into the atmosphere but rather is covered with a filtration cap.

For all their apparent simplicity all these technical solutions have definite drawbacks. The best result in designing effective suction systems is achieved not only by simple modification of one or another model of a filter, cyclone se-

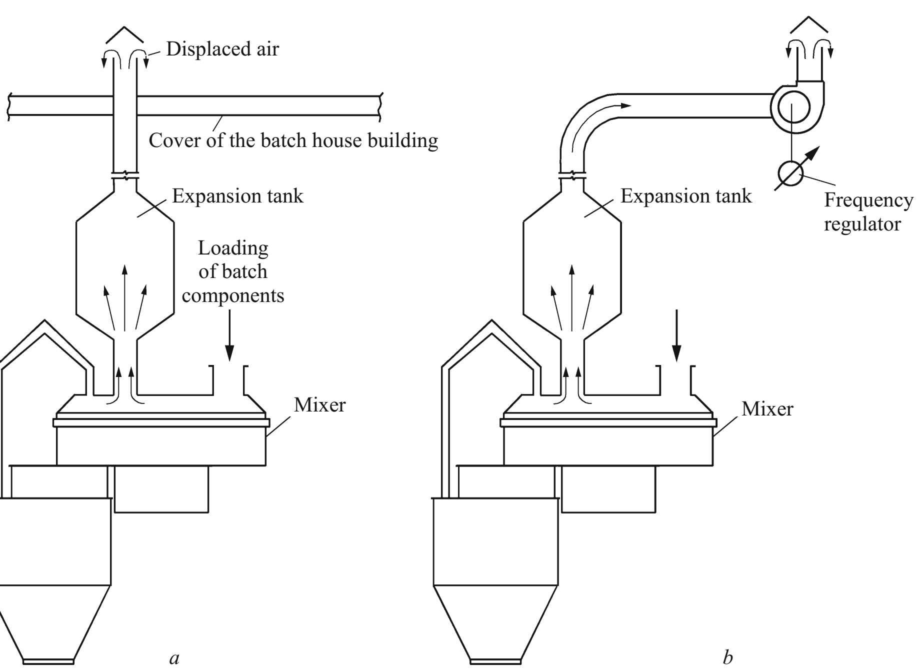

Fig. 4. Installation of an aeration expansion tank on a mixer: *a*) natural suctioning; *b*) forced suctioning.

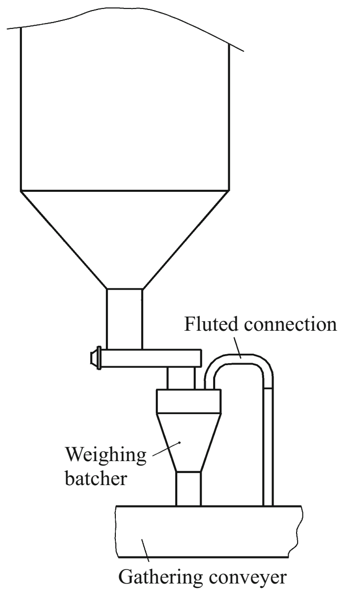

Fig. 5. Suction connection of a tensometric weighing batcher.

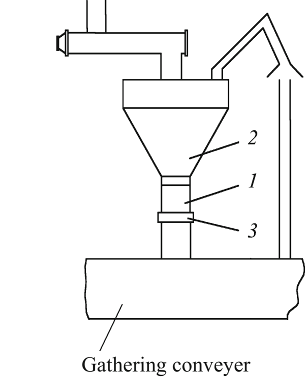

Fig. 6. Suction connection piece of a tensometric weighing batcher with an air-regulated gate.

parator or other apparatus but also by applying a comprehensive approach to the questions of building and technological outfitting of the batch house, selecting the main and auxiliary equipment of the BML and developing optimal control algorithms.

Other problems associated not only with the operations of mixing and wetting the raw materials but also with batching the materials are also solved in the course of designing suction systems for BML, since precise operation of tensometric weighing batchers (this especially concerns batching minor components of glass batch) depends directly on the degree of rarefaction created by the suction equipment in the mixer and interior volume of the cover on the gathering conveyer. To eliminate this undesirable effect on the accuracy of weighing raw materials (200 – 300 g) caused by the difference between the atmospheric pressure and the pressure inside the suctioned equipment fluted connection pieces are installed (Fig. 5). These connections connect the covers of the tensometric batchers with the covers of gathering conveyers and perform two functions: they equalize the pressure between the assemblies and bleed air from the weighing batchers as they are being filled with material.

The state of the fluted connections must be continually monitored, since they gradually become clogged with dust and less flexible and thereby introduce definite errors into the operation of the weighing systems. For this reason, other types of connections are used instead of fluted plastic connections (Fig. 6). They consist of two metal tubes *1*, *2* which are coupled with one another by means of an air-regulated valve *3* in the form of an inverted conical funnel *4*. Usually, such an apparatus is also used to equalize the pressure in the hoppers receiving batch off-loaded from the mixers, which is especially important if these hoppers are placed on weighing sensors controlling the completion of the unloading of the mixer and preventing a second portion from entering the hopper.

Additional technical measures which improve the operation of weighing equipment and increase the weighing accuracy for raw materials include mounting cut-off slide gates and sluice gates in the unloading chute in batching and batching-mixing complexes for minor components of glass batch, such as sulfate, carbon, colorants, admixtures of selenium and cobalt and other decolorants of the molten glass.

Sluice gates (Fig. 7), consisting of two disk slides *1*, *2*, just as during their operation in a complex with a bag filter, protect the mechanism of the rotary cup *3* of the micro-additive batcher *4* from moist and dusty air and prevent possible fluctuations caused in the sensitivity of the weighing-measuring system of the minor-components batcher by a change of the air pressure inside the mixer *5*. This problem can also be eliminated by a different method, if the batched micro-additives and their pre-mixes are not loaded directly into the

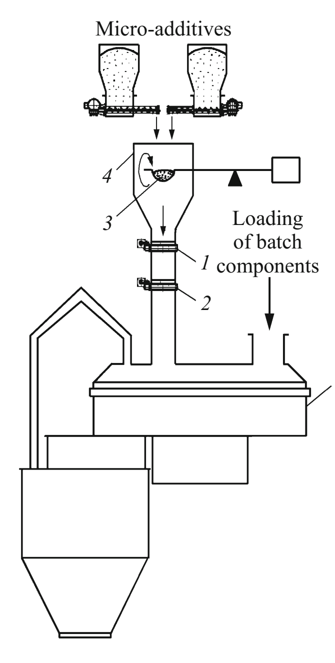

Fig. 7. Installation of a sluice gate on the unloading connection of a micro-additives batcher.

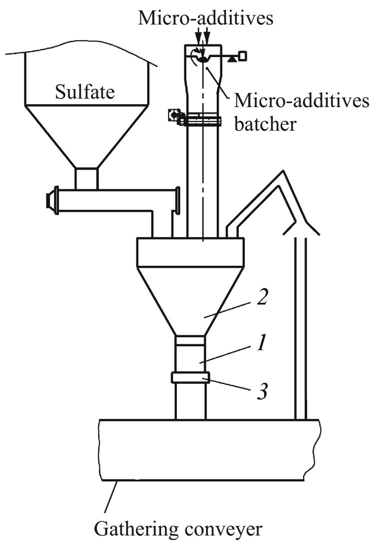

Fig. 8. Unloading of micro-additives through a minor-components batcher.

mixer but rather first fed into the batcher of sulfate or other material component added to the batch in small quantities (Fig. 8), whence they are off-loaded onto the gathering conveyer together. In addition, the unloading cute *1* of this batcher *2* must contain without fail a cut-off slide gate *3*, which prevents the suction system from affecting the weighing accuracy. Ignoring this requirement for small-portion batchers can result in inadmissible batching errors (several hundreds of grams) due to the pulling force, which results in spurious actuations of the control system that fixes either the "discharge tare of the batcher" or the leakage of raw material from the cut-off gate of the load feeder or premature filling of the hopper of the weighing balances. However, the batchers of sand, soda, dolomite, and other materials unrelated with the minor additives are less sensitive to fluctuations of the pressure inside the gathering conveyer, so that additional slide gates are added to their design.

The process of designing BML suction systems based on mobile batching complexes [2] has other particularities due to the horizontal arrangement and length of such weighing lines as well as the large number of positions for loading and unloading materials. As a rule, these systems are centralized and equipped with stationary dust-catching equipment and a branching network of air ducts and connections with suction slits and regulated slide gates. The air ducts, which have long horizontal sections, are constantly being clogged with dust; materials caught by cyclone separators and filters are not recycled into the technological process but rather must be salvaged.

Most effective systems are mobile suction systems [3] of weighing carts. In these systems the sealing joining units, which prevent dusting of the batched material as it is loaded into a weighing hopper and then unloaded in the mixer, as well as a bag filter, compressed air receiver and pneumatic drives of the joining mechanism and rotary disk gates are placed directly on a cart. This solution not only greatly reduces the total number of drives in the system but it also reduces considerably the losses of the components of the glass batch.

In summary, the development and adoption of effective solutions in the design of modern suction systems for BML make it possible to increase the quality of the batches and different multicomponent mixtures which are prepared and to improve the sanitary state of batch houses and batching-mixing compartments.

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